

General Disclaimer

One or more of the Following Statements may affect this Document

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.
- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.
- This document may contain tone-on-tone or color graphs, charts and/or pictures, which have been reproduced in black and white.
- This document is paginated as submitted by the original source.
- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

DOE/NASA CONTRACTOR REPORT

DOE/NASA CR-150728

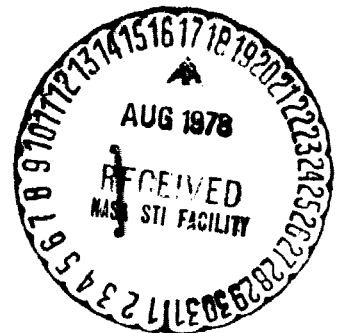
COLLATION OF MONTHLY AND SEMI-ANNUAL REPORTS COVERING INSTRUMENTATION AT THE "DECADE 80" HOUSE IN TUCSON, ARIZONA

Prepared by

Copper Development Association, Inc.
405 Lexington Avenue
New York, New York 10017

Under Contract NAS8-32244 with

National Aeronautics and Space Administration
George C. Marshall Space Flight Center, Alabama
For the U. S. Department of Energy



(NASA-CR-150728) COLLATION OF MONTHLY AND
SEMIANNUAL REPORTS COVERING INSTRUMENTATION
AT THE DECADE 80 HOUSE IN TUCSON, ARIZONA
(Copper Development Association, Inc.) 24 p
HC A02/MF A01

N78-28609

CSCL 10B G3/44

Unclass
27150

U.S. Department of Energy



Solar Energy

TABLE OF CONTENTS

Semi Annual Report	1
Monthly Status Report No. 1 - December 1976	5
Monthly Status Report No. 2 - January 1977	6
Monthly Status Report No. 3 - February 1977	7
Monthly Status Report No. 4 - March 1977	8
Monthly Status Report No. 5 - April 1977	9
Monthly Status Report No. 6 - May 1977	10
Monthly Status Report No. 8 - July 1977	11
Monthly Status Report No. 9 - August 1977	12
Monthly Status Report No. 10 - October 1977	13
Monthly Status Report No. 11 - November 1977	14
Monthly Status Report No. 12 - December 1977	15
Monthly Status Report No. 13 - January 1978	16
Monthly Status Report No. 14 - February 1978	17
Monthly Status Report No. 15 - March 1978	18
Monthly Status Report No. 16 - April 1978	20

Semi-Annual Report

INSTRUMENTATION AND DATA ACQUISITION PROGRAM AT

THE DECADE 80 SOLAR HOUSE

NAS8-32244

Russell K. Johnson
W. Stuart Lyman

The program to instrument the solar heating and cooling system at the Decade 80 Solar House, and to acquire performance data on the system, began with the effective date of the contract on November 23, 1976. The initial task was the preparation of a proposed instrumentation plan to identify the type and location of the measurements needed.

Instrumentation Plan

The proposed instrumentation plan was submitted on January 15, 1977 and the Prototype Design Review meeting with the NASA Technical Manager followed on January 28, in New York City.

During February work proceeded to refine the instrumentation system design, working with the Technical Manager and the associate contractor (IBM) on the project. Final revisions to the plan were agreed to in March, and the revised proposed instrumentation plan was accepted by the Government and work began at the site to prepare for the arrival of the Government-furnished sensors and Site Data Acquisition System (SDAS). A summary chronology of the work from that point on is shown in Table 1.

TABLE 1. CHRONOLOGY OF EVENTS. Installation and Performance of the Site Data Acquisition System at the Decade 80 Solar House in Tucson.

1977

April

- Pulled sensor cables from mechanical rooms to computer closet.

May

- Computer closet air conditioner installed.
- Phone DAA installed.
- Temperature wells and flow sensors installed; watt transducers installed.
- J-box installed.

June

- Sensors wired to J-box.
- Two sensors replaced.
- SDAS mounted in computer room.
- SDAS started up and tested.
- Air flow sensor found to be defective.
- Installation Acceptance Review Meeting held in Tucson, June 14.

July

- Several flow sensors down due to power supply failure.
- New Sierra air flow sensor installed.
- SDAS failure - returned to Huntsville for repair, June 26.

August

- SDAS re-installed, August 13.

September

- SDAS erratic due to accidental shutoff of computer closet air conditioner.
- SDAS failed due to magnetic tape becoming tangled around idler wheel.
- W403 connections appeared to be intermittent; problem corrected.

October

- IBM crew repaired SDAS and installed new magnetic tape.
- EP600 wiring error corrected: P-1 wired through sensors wrong.
- Inaccuracies discovered in temperature sensors TD100, TD200, TD450, TD451.

November

- Attempted to sort T/TD450 leads for more accurate differential measurement.
- IBM representative visited to calibrate temperature sensors.
- EP600 wiring corrected again, due to P-1 motor modification and erroneous connection of pump to transducer.

December

- Flow through P-4 decreased to lengthen integration time; W403 could not read the lower flow; flow raised back to 12 gpm.
- Computer closet air conditioner replaced by a fan drawing in outside air; room overheated and SDAS sent erratic data, December 16.

1978

January

- Installed new EP500 and EP600; tripled output of EP601; EP500 wiring corrected on January 5; EP600 wiring error corrected on January 12
- Telephone handset removed from data coupler by phone company.
- Data reviewed and compared with CDA's data at semi-annual review at NASA, Huntsville.
- Totalizing water meter installed to replace W301.
- Armaflex insulation installed on all high-temperature weatherheads.
- Studied data to find cause of a spike in the TD100 readings; disabled P-1 overnight without affecting spike; closed valve in collector loop overnight, eliminating spike.

February

- IBM/Wyle crew replaced several circuit boards in SDAS and calibrated temperature sensors.

Site Data Acquisition System

The SDAS was installed and tested early in June and the Installation Acceptance Review meeting was held with the Technical Manager and a representative of IBM in Tucson on June 14. One air-flow sensor was found to be defective.

In July, it was established that nine water-flow sensors lacked the power needed to function due to either a fault or a malfunction in the SDAS and on July 15 the SDAS was observed to be completely inoperative. The SDAS was then retrieved by IBM who subsequently brought it back and re-installed it on August 13.

As the SDAS began to function, and IBM was able to review the output being received in Huntsville, it was possible to isolate problems in sensor calibration and operation, as summarized in Table 1. By the end of January, the SDAS was fully operational and was transmitting complete enough data to Huntsville for meaningful analysis of system performance to begin.

Solar Heating and Cooling System

During the period of shakedown and debugging of the SDAS and its associated sensors, the solar heating and cooling system at the house functioned without major incident. Two minor component failures were easily dealt with: a pane of collector glass broke due to thermal shock when the collector was started up at 1:00 p.m. after installing the W100 flow

sensor, and valve V-3 (a motorized valve) failed due to leakage of hydraulic fluid after its long idle period in the summer probably due to the seal drying out. Addition of hydraulic fluid solved the problem.

Pumps P-1 and P-6 were replaced to recover decreased flow due to the instrumentation system flow meters. The impeller in pump P-2 was replaced for the same reason. There was some slight leakage from the seals in the new pumps until they became properly worn-in and seated.

Leakage at the unions for sensors W100 and W200 and W403 necessitated several service calls. Dielectric unions (with rubber gaskets) were initially used, but they could not tolerate system operating temperatures and leaked. The leaking unions were finally replaced with brass unions or adaptors.

Future Plans

Complete performance data should be available for the month of February and from then on through the end of the heating season and for the first few weeks of the cooling season. Then the system will be shut down in the month of May for major modifications, chiefly the installation of a Government-furnished programmable control system and the replacement of the present direct-air-cooling Arkla machines with two new Arkla water chillers. The system should be returned to full function in early June, permitting performance data collection for the cooling season.



copper development

association inc.

405 Lexington Avenue, New York, N.Y. 10017 COPPERDEV NEW YORK (212) 953-7300

January 7, 1977

Mr. Mitchell Cash
(Mail Code FA32)
NASA
George C. Marshall Space Flight Center
Marshall Space Flight Center
Alabama 35812

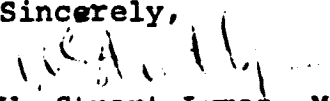
Dear Mr. Cash:

Monthly Status Report No. 1
CONTRACT NAS8-32244

During the month of December 1976, work proceeded on schedule to determine the work required to install the Government furnished Site Data Acquisition Subsystem.

The results of this analysis, which will constitute the Prototype Design Review Data package, will be submitted to the Technical Managers by January 14 in anticipation of the Prototype Design Review meeting in New York City on January 28, 1977.

Sincerely,


W. Stuart Lyman, Manager
Technical & Market Services

WSL:mfg



copper development

association inc.

405 Lexington Avenue, New York, N.Y. 10017 COPPERDEV NEW YORK (212) 953-7300

February 7, 1977

Mr. Mitchell Cash
(Mail Code FA32)
NASA
George C. Marshall Space Flight Center
Marshall Space Flight Center
Alabama 35812

Dear Mr. Cash:

Monthly Status Report No. 2
CONTRACT NAS8-32244

During the month of January 1977, work proceeded on schedule to determine the requirements to install the Government furnished Site Data Acquisition Subsystem.

The Prototype Design Review Data package was submitted to the Technical Managers on January 14 and the Prototype Design Review meeting was held in New York City on January 28, 1977.

Sincerely,

W. Stuart Lyman (1/11)
W. Stuart Lyman, Manager
Technical & Market Services

WSL:mfg



copper development

association inc.

405 Lexington Avenue, New York, N.Y. 10017 COPPERDEV NEW YORK (212) 953-7300

March 15, 1977

Mr. Mitchell Cash
(Mail Code FA32)
NASA
George C. Marshall Space Flight Center
Marshall Space Flight Center
Alabama 35812

Dear Mr. Cash:

Monthly Status Report No. 3
CONTRACT NAS8-32244

During the month of February 1977, work proceeded, working with the Technical Manager and the Associate Contractor to refine the details of the instrumentation plan.

Sincerely,


W. Stuart Lyman, Manager
Technical & Market Services

WSL:mfg



copper development

association inc.

405 Lexington Avenue, New York, N.Y. 10017 COPPERDEV NEW YORK (212) 953-7300

April 6, 1977

Mr. Mitchell C. Cash (Mail Code FA32)
NASA George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

Dear Mr. Cash:

Monthly Status Report No. 4
CONTRACT NAS8-32244

During the month of March 1977, the final revisions to the proposed instrumentation plan were agreed to with the Technical Manager and the Associate Contractor and the revised proposed instrumentation plan was accepted by the Government.

Some preliminary work was done in anticipation of receipt of the sensors.

Sincerely,


W. Stuart Lyman, Manager
Technical & Market Services

WSL:mfg



copper development

association inc.

405 Lexington Avenue, New York, N.Y. 10017 COPPERDEV NEW YORK (212) 953-7300

May 18, 1977

Mr. Mitchell C. Cash (Mail Code FA32)
NASA George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

Dear Mr. Cash:

Monthly Status Report No. 5
CONTRACT NAS8-32244

During the month of April 1977, work began in preparation for receipt of the Government-furnished sensors for the instrumentation system. The work consisted mainly of installation of the sensor cables.

Sincerely,

W. Stuart Lyman, Manager
Technical & Market Services

WSL:mfg



copper development

association inc.

405 Lexington Avenue, New York, N.Y. 10017 COPPERDEV NEW YORK (212) 953-7300

June 13, 1977

Mr. Mitchell C. Cash (Mail Code FA32)
NASA George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

Dear Mr. Cash:

Monthly Status Report No. 6
CONTRACT NAS8-32244

During the month of May, the on-site work to install the on-site instrumentation throughout the solar collection, energy transport, storage, and heating and cooling system was essentially accomplished. The Government-furnished sensors and junction box were also installed. The site data acquisition system had not yet been received at the end of May.

The installation acceptance review meeting is scheduled for June 14.

Sincerely,

W. Stuart Lyman, Manager
Technical & Market Services

WSL:mfg

Copper Development Association Inc.

405 Lexington Avenue, New York, N.Y. 10017 COMPENDEX NEW YORK (212) 221-1111

August 11, 1977

Mr. Mitchell C. Cash (Mail Code FA32)
NASA George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

Dear Mr. Cash:

Monthly Status Report No. 8
CONTRACT NAS8-32244

The month began with all sensors installed and the Site Data Acquisition System (SDAS) in place and functioning except for: (1) the air flow sensor which had been removed for repair by the associate contractor (IBM) and (2) nine water flow sensors which lacked power needed to function due to a fault or malfunction in the SDAS.

On July 15 the SDAS was observed to be inoperative and IBM was informed. An IBM representative visited the site on July 25 and left with the SDAS to repair it on July 26. The unit had not been returned at the end of the month.

Sincerely,

W. Stuart Lyman
W. Stuart Lyman, Manager
Technical & Market Services

WSL:mfg

ORIGINAL REPRODUCED
OF POOR QUALITY

copper development

association inc.

405 Lexington Avenue, New York, N.Y. 10017

COPPERDEV NEW YORK (212) 953-7300

October 18, 1977

Mr. Mitchell C. Cash (Mail Code FA32)
NASA George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

Dear Mr. Cash:

Monthly Status Report No. 9

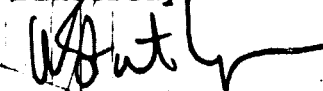
CONTRACT NAS8-32244

The Site Data Acquisition System had failed in July and then was returned to IBM for service. It was brought back to the site and installed by three IBM representatives on August 13. There were no further problems with the SDAS in August.

On or about August 30, a gasket in the union supporting W-200 began to leak. The dripping water shorted a fuse-stat at P-2, tripping its circuit breaker. The storage tank lost pressurization, causing P-3 and P-10 to cavitate, and giving the boiler and the ARKLAS inadequate flows. (These problems were corrected on September 1.)

A program to improve the efficiency of the system's electric motors was begun. The modification known as the Wanlass "Controlled Torque" has been made on the cooling tower fan and the ARKLA blower motors. Similar future modifications are planned for Pumps P-1, P-2, P-3 and P-6.

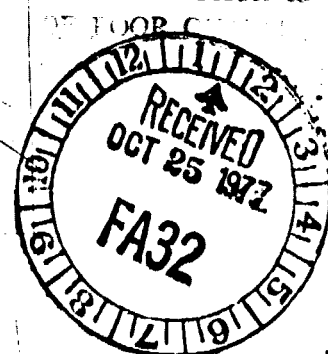
Sincerely,



W. Stuart Lyman, Manager
Technical & Market Services

WSL:e

ORIGINAL PAGE IS





copper development

association inc.

405 Lexington Avenue, New York, N.Y. 10017 COPPERDEV NEW YORK (212) 953-7300

November 23, 1977

Mr. Mitchell C. Cash (Mail Code FA32)
NASA George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

Dear Mr. Cash:

Monthly Status Report No. 10

CONTRACT NAS8-32244

The SDAS was down when the month began, as confirmed by the contractor's engineer when he returned to Tucson on October 3. Eventually the system became fully operational again on October 12 when repairs were made to the SDAS in the course of a site visit by two representatives of the associate contractor (IBM).

On October 14 logic diagrams for the Decade 80 solar energy system controls were forwarded to the associate contractor.

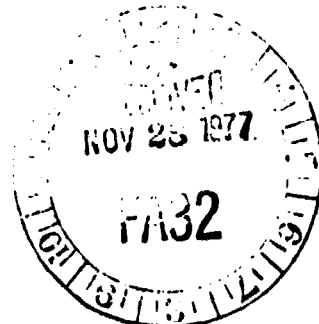
Some problems with leaking flow sensor installations (W-200 and W-201) were experienced during the month but appeared to be solved by October 20.

On October 18 new pumps P-1 and P-6 were installed. Eventually, these pumps will be modified by the Wanlass capacitor circuit method to improve their efficiency. New pump P-1 increased flow in the collector loop by 20-25%.

Sincerely,

W. Stuart Lyman, Manager
Technical & Market Services

WSL:mfg





copper development

association inc.

405 Lexington Avenue, New York, N.Y. 10017 COPPERDEV NEW YORK (212) 953-7300

December 19, 1977

Mr. Mitchell C. Cash (Mail Code FA32)
NASA George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

Dear Mr. Cash:

Monthly Status Report No. 11

CONTRACT NAS8-32244

During November there were continuing problems with sensors W403, TD100, T/TD200, T/TD450, and T/TD451. At the request of the associate contractor (IBM) these sensors were checked and their connectors recrimped and their resistances measured. No problems were found in this way.

Two representatives of IBM visited the site on November 14-17. Several temperature sensors were identified as being outside factory specifications during that inspection. They are scheduled to be replaced.

To investigate storage tank losses, the domestic hot water (DHW) circuit was turned down to 80F on November 10. The DHW pumps still cycled occasionally, so they were turned off for several days starting November 14.

At the beginning of the month, the collector was purged of air and a temperature scan made to examine flow patterns. The collector array plumbing was then rebalanced on November 2nd. A slight decrease in flow may have resulted and be noted in the data.

Sincerely,

W. Stuart Lyman (24)
W. Stuart Lyman, Manager
Technical & Market Services

WSL:mfg



copper development

association inc.

405 Lexington Avenue, New York, N.Y. 10017 COPPERDEV NEW YORK (212) 953-7300

January 19, 1978

Mr. Mitchell C. Cash (Mail Code FA32)
NASA George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

Dear Mr. Cash:

Monthly Status Report No. 12
CONTRACT NAS8-32244

During December the SDAS system operated with only the following notable incidents:

On December 8 it was noted that sensor EP600 was not putting out any signal. This was due to a wiring error made in the course of working on a pump motor and was corrected the same day.

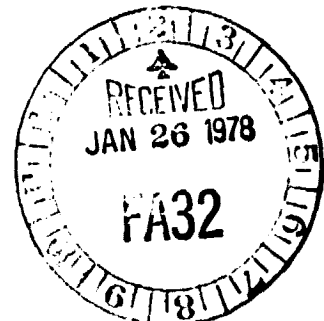
On December 18 the SDAS became erratic due to the air conditioner in the instrument closet having been shut off.

On December 28, at the request of the associate contractor (IBM), sensor W-300 was checked out to ascertain the reason for it not putting out a signal. The lack of signal proved to be due to the fact that there was no flow. The lack of flow was because the domestic hot water system was on auxiliary due to low storage tank temperature.

Sincerely,


W. Stuart Lyman, Manager
Technical & Market Services

WSL:mfg





copper development

association inc.

405 Lexington Avenue, New York, N.Y. 10017 COPPERDEV NEW YORK (212) 953-7300

February 14, 1978

Mr. Mitchell C. Cash (Mail Code FA32)
NASA George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

Dear Mr. Cash:

Monthly Status Report No. 13
CONTRACT NAS8-32244

During January the SDAS system operated with only the following notable incidents:

January 3: New sensors EP500 and EP600 were installed with double the output of their predecessors; EP601 was modified for triple output.

January 5: Polarity error was corrected for sensors EP500 and 600.

January 24: A totalizing water meter was installed to replace the previous sensor W301. Circulating pump P9 was shut off in order to study losses in the domestic hot water system.

January 26: Locations were checked for two sensors; W500 was found to be located as marked on the system drawing but sensor T503 was found to be in error. The drawing has been corrected.

January 30: The temperature sensor weatherheads were insulated with ARMAFLEX insulation.

January 31: Studies were completed to establish the cause of the late evening spike noted on the printout draft for sensor TD100. The spike appears to be due to spontaneous thermal circulation.

The semi-annual project review meeting was scheduled for Huntsville, Alabama on January 24. Due to weather-caused airline scheduled cancellations the meeting actually occurred in two parts: On January 24 when R. K. Johnson met with you at NASA and on January 30 when I did.

Sincerely,


W. Stuart Lyman, Manager
Technical & Market Services

WSL:mfg



copper development

association inc.

405 Lexington Avenue, New York, N.Y. 10017 COPPERDEV NEW YORK (212) 953-7300

April 3, 1978

Mr. Mitchell C. Cash (Mail Code FA32)
NASA George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

Dear Mr. Cash:

Monthly Status Report No. 14
CONTRACT NAS8-32244

During February the SDAS system and associated hardware operated with only the following notable incidents:

February 1-2: Cecil Messer of NASA visited the site.

February 3-4: Representatives from IBM and from Wyle Laboratories visited the site to replace several circuit boards in the SDAS and to calibrate sensors. They also replaced most of the temperature differential measurement sensors with absolute measurements and assigned new numbers to many sensors.

February 18: Representatives of IBM again visited the site and repaired some loose wires in the J-Box. They also found some reversed wiring in the J-Box. Also, they found sensor T-200 to be defective.

February 20: A problem developed with pump P2 and was repaired.

February 22: Flow sensor W301 was returned to IBM.

February 27: Gas flow meter F400 was found to be giving erroneous readings. Troubleshooting on site at IBM's request revealed no wiring problems in the J-Box.

Sincerely,


W. Stuart Lyman, Manager
Technical & Market Services

WSL:mfg



copper development

association inc.

405 Lexington Avenue, New York, N.Y. 10017 COPPERDEV NEW YORK (212) 953-7300

April 20, 1978

Mr. Mitchell C. Cash (Mail Code FA32)
NASA George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

Dear Mr. Cash:

Monthly Status Report No. 15
CONTRACT NAS8-32244

During March the SDAS system operated with only the following notable incidents:

March 1: Weekly gas flow measurements for February were provided to Ken Roberts of IBM.

March 2: Valve V4 was found to be not operating.

March 6: Valve V4 was restored to service.

March 13: Mr. Ken Roberts of IBM reported that his data indicated control sensor T5 in the system was set too low and as a result some domestic hot water energy went to the storage tank.

March 15: Control sensor T5 was adjusted upward five degrees.

March 21-22: IBM representative Henry Wattenberger visited the site and replaced 5 temperature sensors: T200, T250, T403, T450, T451 with newly-calibrated sensors. Also, a new potentiometer was installed in W400, the gas flow meter, and a new sender unit was put in W301, the domestic hot water flow meter.

March 22-23: Propylene glycol data and a sample was sent to the technical manager.

March 23: The cooling tower was filled and prepared for the air conditioning season.

March 28: A sample of the collector loop fluid was taken and tested. The phosphate inhibitor level was found to be 2,550 ppm.


Mr. Mitchell Cash
April 20, 1978

March 29: IBM reported that pump P2 appeared to have been running continuously since March 23. When checked the manual override switch was found to be in the on position.

On March 20. R. K. Johnson and W. S. Lyman visited Andover Controls, Andover, Mass., to inspect and discuss the Andover "Sunkeeper" programmable control system. The system appears to be ideally adapted to controlling the Decade 80 solar energy system. The only drawbacks noted were a requirement for a 300 baud terminal for programming the equipment and a requirement for a fairly expensive NEMA junction box for the wiring and relays.

On March 24, R. K. Johnson visited Rho Sigma in North Hollywood, California to inspect the RS600 programmable controller. This unit does not really have the capacity to handle the Decade 80 system and also is much less flexible than the Andover unit.

Sincerely,


W. Stuart Lyman, Manager
Technical & Market Services

WSL:mfg



copper development

association inc.

405 Lexington Avenue, New York, N.Y. 10017 COPPERDEV NEW YORK (212) 953-7300

May 25, 1978

Mr. Mitchell C. Cash (Mail Code FA32)
NASA George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

Dear Mr. Cash:

Monthly Status Report No. 16
CONTRACT NAS8-32244

During April the SDAS data collection project at the Decade 80 Solar House operated with only the following notable incidents:

- April 10 - Measurements and observations of the operation of the air compressor which maintains pressure in the ullage of the storage tank indicated that the compressor operates a total of about 5 minutes per day.
- April 11 - At the suggestion of the Associate Contractor (IBM), the differential thermostat setting which controls the operation of pump P2 was increased from 6 degrees F to 10 degrees. This is the temperature differential between the storage tank and the water leaving the collector.
 - At the request of IBM several signal conditioning voltages were checked at the J-box.
- April 14 - The differential temperature setting referred to above was reduced from 10 degrees to 8 degrees F.
- April 20 - Sets of the new piping and control diagrams were mailed to the Technical Manager and to IBM.
- April 21 - At the request of IBM connections in the J-box for sensors T250 and T350 were changed.

Mr. Mitchell C. Cash
May 25, 1978

- It was discovered that the fuse on pump P1 had blown and a review of the CDA on-site data collection system revealed the incident had occurred in the early afternoon of April 19. This meant that the collector had been in a stalled condition for the better part of two days.
- Consultation with IBM revealed that the collector had reached a maximum temperature of 298 F on the first day and 286 F on the second.
- It was also discovered that the thermal overload on the air conditioner serving the data room (closet) where the SDAS, the J-box, and the on-site CDA programmable calculator are housed had also burned out on the afternoon of April 19. The time was known from the strip chart recorder in the data room which maintains a record of room temperature. The data room reached a temperature of 115 F at 8:00 p.m. on the 19th and about 125 F at 5:00 p.m. on the 20th.

April 24 - Repairs on the data room air conditioner were completed.

April 25 - At the request of IBM, J-box connections were exchanged between channels 14 and 43.

Sincerely,


W. Stuart Lyman, Manager
Technical & Market Services

WSL:mfg